

## **SECTION 15978**

### **ADJUSTABLE FREQUENCY DRIVES**

#### **PART 1 - GENERAL**

##### **1.1 DESCRIPTION**

- A. Description of systems:
  - 1. Adjustable frequency drives, PWM.

##### **1.2 QUALITY ASSURANCE**

- A. Manufacturer shall have a minimum of 7 years in manufacture and operation of PWM drives in size(s) indicated.
- B. UL listed and labeled, Canadian Standards Association listed and labeled, and/or Electrical Testing Laboratories listed and labeled.
- C. Tested to ANSI/UL-508.
- D. Meet requirements of IEEE Standard 519, latest edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters".
- E. FCC Rules and Regulations, Part 15, Subpart J for Class A Computing Devices.
- F. Local service representative's qualifications:
  - 1. Provide and maintain field service personnel authorized by Manufacturer to perform service both in and out of warranty.
  - 2. Maintain full stock of service parts for all units furnished.
  - 3. Provide in-depth training in operation of all units.

##### **1.3 SUBMITTALS**

- A. Shop drawings:
  - 1. Dimensional drawings.
  - 2. Power circuit drawings.
  - 3. Control connection drawings.
  - 4. Harmonic analysis.
  - 5. Certification of compliance with FCC rules and regulations, Part 15, subpartJ.
- B. Product data:
  - 1. AFD's maximum rated output amps.
- C. Contract closeout information:
  - 1. Operating and maintenance data.
  - 2. Government instruction report.
  - 3. Factory start-up and field test reports.
  - 4. Warranty.

##### **1.4 WARRANTY**

- A. Warranty:
  - 1. 12 months from date of start up, not to exceed 18 months from date of shipment.
    - a. Include all parts, labor, travel time and expenses.

#### **PART 2 - PRODUCTS**

##### **2.1 ADJUSTABLE FREQUENCY DRIVES - GENERAL**

- A. Acceptable manufacturers:
  - 1. Adjustable frequency drives, pulse width modulated:
    - a. Base:
      - 1) Asea Brown Boveri.
    - b. Optional:
      - 1) Danfoss Graham Drives.
      - 2) Magnetek.
      - 3) Reliance Electric.
      - 4) Toshiba.
      - 5) Utec/Unico Inc.
  - 2. Fuses:
    - a. Base:
      - 1) Bussmann.
      - 2) Shawmut.
      - 3) Reliance Electric.
  - 3. Other manufacturers desiring approval comply with Document 00440.
- B. General requirement for adjustable frequency drives:
  - 1. Adjustable frequency in proportion to output speed.
  - 2. Adjustable output voltage with constant volts/Hz over a variable torque output range.
  - 3. Supply full rated current at frequency within a variable torque output range.
  - 4. Develop full shaft power needed.
- C. Adjustable frequency drives shall be checked against each motor's total amperage, and current limiting overload control shall be properly set.
- D. Adjustable frequency drives and associated motors shall be compatible without motor deration.
- E. Motor noise as a result of AFD: Limited to three dB over across line operation, measured at three feet from motor's center line.

## **2.2 ADJUSTABLE FREQUENCY DRIVES (AFD'S)**

- A. Adjustable frequency drives (AFD): Provide rectifiers to convert three-phase, 60 Hz AC power to DC power and inverters to “invert” DC power back to a variable voltage and variable frequency, three-phase AC power.
  - 1. Provide input fused disconnect switch or combination circuit breaker and fuse to disconnect drive, by-pass and all accessories.
    - a. Fuses to be provided by AFD manufacturer.
    - b. Provisions for padlock in off position.
  - 2. AFD shall be rated for 100,000 Amp interrupting capacity (AIC).
  - 3. Enclosed in NEMA 1 enclosure including accessories, completely assembled and tested; or all components provided in a single factory supplied racking system with components and accessories assembled, wired and factory tested.
  - 4. Harmonic mitigation:
    - a. As a minimum, each AFD shall be provided with a 3 percent input AC line reactor mounted within the AFD enclosure.
  - 5. Drive efficiency: 97 percent or greater at full speed and full load.
  - 6. Displacement power factor: 0.95 at all speeds and loads.
  - 7. Switching frequency adjustable over minimum range of 1.0 to 12.0 kHz.
- B. Rectifier section: Full wave diode bridge rectifier. Phase controlled rectifiers are unacceptable.
- C. DC bus linking rectifier and inverter.
- D. Inverter section: Pulse width modulated voltage source inverter (PWM).
  - 1. Output voltage shall vary with frequency using insulated gate bipolar transistors (IGBT). VVI, six-step, current source, SCR, GTO, and bipolar junction transistor (BJT or Darlington pair transistors) drives are not acceptable.

- E. Printed circuit boards: Completely tested and burned-in before being assembled into completed adjustable frequency drive.
  - 1. Subject adjustable frequency drive to a preliminary functional test, eight hour burn-in, and computerized final test.
  - 2. Burn-in shall be at 104 degF, at full rated load, or cycled load.
  - 3. Drive input power: Continuously cycled for maximum stress and thermal variation.
- F. Environmental operating conditions:
  - 1. 32 to 104 degF at 3kHz switching frequency.
  - 2. 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing.
  - 3. Atmosphere: Standard equipment room environment.
- G. Additional requirements:
  - 1. Provide same control interface and connections regardless of horsepower rating.
  - 2. On loss of input signal:
    - a. Display a fault condition.
    - b. Maintain last output speed prior to loss of signal.
  - 3. Utilize digital display (LCD or LED).
  - 4. Automatically restart after an overcurrent, overvoltage, under-voltage, loss of input signal protective trip or any other fault.
    - a. Number of restart attempts and trial time to be programmable.
  - 5. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage.
  - 6. Provide an automatic extended power loss ride-through circuit which will utilize inertia of load to keep drive powered.
    - a. Minimum power loss ride-through: One-cycle or extended time.
  - 7. Control terminal strip: Isolated from line and ground.
  - 8. Provide prewired 3-position Hand-Off-Auto switch, manual speed adjustment (keypad or potentiometer) and local-remote switch to control AFD.
    - a. When in "Hand" position, AFD will be started.
    - b. When in "Off" position, AFD will be stopped.
    - c. When in "Auto" position, AFD will start via an external contact closure.
    - d. When local-remote switch is in "Local" position, speed will be controlled by manual speed.
    - e. When local-remote switch is in "Remote" position, speed will be controlled by external speed reference.
    - f. Operate local-remote switch independently of HOA switch for maximum flexibility.
      - 1) Control speed by manual speed adjustment or external speed reference by selecting "Local" or "Remote" regardless of whether HOA is in "Hand" or "Auto" position.
- H. Provide following adjustments:
  - 1. A minimum of 3 critical frequency lockout ranges to prevent adjustable frequency drive from continuously operating at an unstable speed.
    - a. Width of each frequency range: Field adjustable.
  - 2. Two programmable analog inputs: Accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller.
    - a. Provide a filter programmable from 0.01 to 10 seconds to remove any oscillation in input signal.
    - b. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.
  - 3. Programmable analog outputs: Proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, or DC bus voltage.
  - 4. Relay outputs:
    - a. Rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; Maximum voltage 300 VDC and 250 VAC; Continuous current rating 2 amps RMS.
  - 5. Independently adjustable acceleration and deceleration rates (1-600 seconds).
  - 6. Ramp or coast to a stop, as selected by user.

7. Provide DC hold and dynamic braking.
- I. Operational information displays:
  1. Output Frequency.
  2. Motor current.
  3. Output voltage.
  4. Motor speed (RPM).
  5. Analog input values.
  6. Elapsed time meter.
  7. Remote speed signal setpoint magnitude.
  8. kWh meter.
- J. Protection circuits: In case of a protective trip, stop drive and display fault condition.
  1. Overcurrent trip: 200 percent of AFD's variable torque current rating.
  2. Overvoltage trip: 130 percent of AFD's rated voltage.
  3. Undervoltage trip: 60 percent of AFD's rated voltage.
  4. Overtemperature: Plus 158 degF.
  5. Ground Fault.
  6. Adaptable electronic motor overload protection:
    - a. Protect motor based on speed, load curve, and external fan parameter.
    - b. Circuits which are not speed dependent are unacceptable.
- K. Speed command input:
  1. Keypad or manual speed potentiometer.
  2. Analog inputs: Each capable of accepting a 0-20 mA 4-20 mA, 0-10 V, 2-10 V signal.
    - a. Input: Isolated from ground, and programmable via keypad for different uses.
    - b. Provide programmable filter to remove any oscillation of the reference signal.
    - c. Filter: Adjustable from 0.01 to 10 seconds.
    - d. Able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed.
    - e. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.
- L. Accessories:
  1. Interlock terminal strip:
    - a. Provide separate terminal strip for connection of freeze, fire, smoke contacts, and external start command.
    - b. External interlocks and start/stop contacts: Remain fully functional whether drive is in Hand, Auto or Bypass.
  2. All wires to be individually numbered at both ends for ease of troubleshooting.
  3. Door interlocked disconnect switch: Padlockable in "Off" position.
  4. Door interlocked magnetic circuit breaker: Disconnect all input power from drive and all internally mounted options.
    - a. Disconnect handle: Thru-the-door type, padlockable in "Off" position.
  5. Manual transfer to line power via three (3) contactors.
    - a. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation.
    - b. Provide a three position selector switch to control bypass drive input and output contactors.
      - 1) Mechanically and electrically interlock bypass and drive output contactors.
      - 2) In "Normal" mode, bypass contactor is open while drive input and output contactors are closed.
      - 3) In "Test" position both bypass and output contactors are open.
      - 4) In "Bypass" position, drive input and output contactors are open, and bypass contactor is closed.
  6. Drive output contactor: Open when drive is stopped, isolating motor from drive.
    - a. Start/stop signals and safety interlocks: Work in drive and bypass modes.

- M. Factory startup test:
  - 1. Provide a certified factory start-up for each drive by factory authorized service center.
    - a. Certified start-up form: Filled out for each drive with a copy provided to Government, and a copy kept on file at Manufacturer.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install in accordance with manufacturer's installation instructions and as specified.
- B. Install free standing units on 4 IN housekeeping pads.
- C. Install wall mounted units to room walls, or on free standing pedestals.
- D. Where AFD's are mounted on air handling unit casing(s), provide bracing and coordinate with air handling unit manufacturer.
- E. Cover and protect units from installation dust and contamination until environment is cleaned and ready for operation.

### **3.2 TESTING AND START UP**

- A. Factory testing:
  - 1. Provide test results to confirm that adjustable frequency drive has been tested to substantiate designs according to applicable ANSI and NEMA Standards.
  - 2. Tests shall verify not only performance of unit and integrated assembly, but also suitability of enclosure venting and rigidity.
  - 3. In addition, unit shall be factory tested in accordance with ANSI Standards.
  - 4. Submit factory test reports.
- B. Field start up and testing:
  - 1. Provide services of a factory trained representative at site to supervise installation and startup.
  - 2. Test machines under operation through full speed range and record data at full load, 75 percent load, 50 percent load and 25 percent load, for a minimum of 1 hour at each load.
  - 3. Field test according to ANSI Standards.

### **3.3 GOVERNMENT INSTRUCTIONS**

- A. Provide services of manufacturer's representative for 8 hours to instruct Government's operating personnel.
  - 1. Instruction hours shall be in addition to testing and startup hours.
- B. Schedule this period when equipment is completely installed and tested and can be operated under normal load.
- C. Provide instruction on each system type.

## **END OF SECTION**